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ABSTRACT

The purpose of this study was to investigate aspects of the Nature of Science (NOS) concepts and teaching practices acquired by inservice teachers who participated in a teacher education program at the National Changhua University of Education in Taiwan. Two instructors used both case-history and demonstration approaches to help science teachers understand NOS concepts and model teaching practices. A questionnaire, Understanding of the Nature of Science Scale (Chinese version), was administered before and after the course. In addition, weekly group discussion reports, teachers' reflective journals, and the instructors' logs were collected during the course processing. Findings revealed that the inservice teachers were impressed by the subjective nature of generating scientific knowledge, and the human nature of the scientists. Thus, the teachers' conceptions of the NOS relative to the subjective and tentative nature of scientific knowledge were changed dramatically as a result of the course. Relative to pedagogy, the teachers indicated a preference for providing concrete activities in the context of group work in order to guide students' understanding of the social negotiation processes and inquiry aspects of the NOS. Factors which influenced the teachers' conceptions of the NOS included their image of scientists and their understandings of the nature of scientific inquiry. The science teachers' views of teaching the NOS were reinforced by their new conceptions of the NOS, by other methods courses, and by the teaching methods used by the instructors in the NOS course. Contains 26 references. (WRM)

What Can Inservice Taiwanese Science Teachers Learn and Teach about the Nature of Science

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What can inservice Taiwanese science teachers learn and teach about the nature of science

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Abstract

An innovative course enhancing inservice science teachers' conceptions and practicing of the NOS was offered in the inservice science teacher education program at the National Changhua University of Education in Taiwan. The purposes of this paper were to investigate aspects of the NOS were acquired by the science teachers, their preferred NOS teaching at the end of the course, and the factors influenced them in acquiring and practicing of the NOS.

Two instructors used both case-history and demonstration approaches to help science teachers to acquire and to practice the NOS teaching.

A questionnaire, "Understanding of the Nature of Science Scale (Chinese version)" (Lin, 1995), was administered before and after the course. In addition, weekly group discussion report, teachers' reflection journal, and instructors' log were collected during the course processing.

Findings revealed that the inservice science teachers were impressed by the subjective nature of generating scientific knowledge, and the human nature of the scientists. Thus these teachers' conceptions of the NOS related to the subjective and tentative nature of scientific knowledge were changed dramatically before and after the course. They also preferred to provide concrete activities and group work learning context, where students could capture the social negotiation process and inquiry nature of the NOS. Factors influenced the science teachers in changing their conceptions of the NOS were their image of the scientists and their understanding of the nature of scientific inquiry. These science teachers' views of teaching the NOS were reinforced by their new conceptions of the NOS, other pedagogy course and the teaching methods used by the instructors.

Key words: nature of science, inservice teacher education, science teacher's conceptions, science teaching

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Introduction

Current reform of science education has addressed the importance of scientific literacy (AAAS, 1993). In fact, Meichtry (1993) summarized the past three decades of scientific literacy reports, which all emphasized the importance of an understanding of the nature of science (NOS). Many research have advocated their effort in investigating many phases related to the NOS, such as: the essence of the NOS (Cobern, 1996; Good, 1996; Lederman, 1996; Mathews, 1996); students' understanding of the NOS(Lucas & Roth, 1996), science teachers' perceptions of the NOS (Abel & Smith, 1994; Carey & Stauss, 1970; Gustafson & Rowell, 1995; Rampal, 1992), and teaching the NOS (Cleminson, 1990; Meichtry,1996).

Unfortunately, research done on the science teachers' perceptions of NOS indicated that not many science teachers hold contemporary views of NOS (Palmquist & Finley, 1997). Without holding current views of the NOS, it is impossible for science teachers to transmit the current view of scientific literacy to their students. Therefore, educating science teachers with current view of NOS become important issue in science education.

Although previous studies done on NOS have indicated the necessity of offering courses addressed the NOS. However, few research had explored in-depth the aspects of the NOS teachers could acquire, the preferred teaching of the NOS, and the factors which influenced teachers' conceptions and practicing the NOS in the course. An innovative course addressed the conceptions and practicing the NOS was offered in the inservice science teacher education program at the National Changhua University of Education in Taiwan. This paper would focus on the aspects of the NOS were acquired by the science teachers, their preferred NOS teaching, and the factors which influenced science teachers in acquiring and practicing the NOS. Thus, the findings of the study could contribute to the NOS literature on better understanding of the teachers' learning and practicing of the NOS. Hopefully, better courses could be designed to enhance future science teachers' understanding and teaching of the NOS.

Theoretical underpinnings

In the literature, there were many definition of the nature of science, Palmquist and Finley (1997) summarized NOS into five categories, these were scientific knowledge, scientific method, scientific theory, scientific law, and the role of scientist. Although there were many faces in the NOS, but it is impossible for students to acquire the whole features of the NOS in the course. Some researchers suggested that the nature of scientific investigations, the nature of scientific knowledge, sociological aspects of science and scientific enterprise could be taught explicitly in

the course (Abd-El-Khalick & Lederman, 1998; Billeh & Hasan, 1975; Ogunniyi, 1983). Others (Lederman & Abd-El-Khalick, in press) advocated the appropriate features of the NOS for k-12 students are the tentative, empirically-based, theory-laden, human inference, imagination, creativity, and socially and culturally embedded nature of scientific knowledge. These features of scientific knowledge were matched with the scientific literacy advocated by current science education (AAAS, 1993)

In terms of the best ways to approach the NOS, Mathews (1998) suggested of inductively and tentatively, but not didactically way are appropriate. He claimed that the case study approach (such as episodes in the history of science, appropriate biographies of scientists, laboratory exercises, or popular writings) could help learners to discuss of, questions about the NOS. He further listed the benefits of using case-history in teaching: promoting better understanding of the science concepts; connecting the development of individual thinking with the development of scientific ideas; enhancing understanding of the nature of science (Mathews, 1994). Other researchers (Duschl, 1990; Garrison & Lawwill, 1993; Lederman, 1992) claimed that history of science could help students to appreciate the nature of scientific enterprise, understanding the relationship between science and society, and the tentative nature of scientific knowledge.

After summarizing the previous research done on improving science teachers' conceptions of the NOS, Abd-El-Khalick and Lederman (1998) indicated that there are two approaches—explicit and implicit ways to improve science teachers' conceptions of the NOS. The explicit approach is to teach the NOS directly in the course, such as using historical case study. The implicit approach is to have teachers with hands-on experience, such as teach teachers science process skills or to have them conduct science experiment. Based on the empirical evidence, explicit approach is more effective than implicit approach in enhancing teachers' conceptions of the NOS.

Palmquist and Finley (1997) investigated fifteen postbaccalaureate secondary science teachers' view of the NOS before and after their teaching methods courses. The findings indicated that before entering the teacher education program, the participants had a contemporary view of scientific theory, knowledge and the role of a scientist, and a traditional view of scientific method. After completing the sequence of teaching method courses which addressed the conceptual change and cooperative learning strategies, the number of contemporary views and mixed views increased. The number of participants with an overall contemporary view of science increased.

Lin (1998a) applied experimental design to assess the effect of using history of science in a preservice teacher education program. The findings indicated that this approach could increased preservice science teachers' fruitful understanding of the

nature of science. In another study, Lin (1998b) investigated sixty college non-science major students' attitude toward science through the history of science. The finding indicated that experimental group of students' attitude toward science and their appreciation of science increased at the end of study.

The above literature all suggested that using case history approach could enhance students' understanding and attitude toward the nature of science.

Design and Procedure

The theoretical framework underpinning the course

There were three theoretical framework in designing the course work. First is using the historical case study, which has been proved as an effective way in enhancing students' understanding of the NOS (Mathews, 1994, 1998; Scharmann & Harris, 1992; Solomon, Duveen, Scot, & McCarthy, 1992).

Second, social constructivist perspective of teaching and learning were applied in the course, where instructors provided historical cases and reading assignments before the class, and provided worksheets and posed group discussion questions for inservice science teachers to discuss, criticize, share and negotiate meaning within group members and among whole classmates. During these processes teachers could construct their conceptions of the nature of science. In addition, the researchers sometimes acted as role model, showed teachers how to learn and teach the NOS, these methods provide an anchoring process for science teachers to construct the NOS teaching.

Third, reflective thinking was also applied in this course, that each teacher has to constantly think of and aware of their previous conceptions of the NOS and their new conceptions of the NOS. Taking reflective journal was the method used in the course to request the participants to practice their reflective thinking.

Context of the course

The integrated science course was a one semester 2 credit hour course designed to help in-service science teachers construct the NOS and teaching of the NOS. Thus, for the first half of the semester, the instructors used case-history approach to help science teachers to acquire the conceptions of the NOS, and for second half of the semester, the instructors provided opportunities for teachers to practice the NOS teaching.

In the first half of the semester, the instructors assigned two case histories "John Snow and Cholera" and "Is Heat a Matter?" and other chapters on "How we know" book (Goldstein & Goldstein, 1978) for science teachers to read, and then to discuss within the group and among the class. Group worksheets were disseminated to the teachers during the class. After group discussing, each group has to present their

findings in front of the whole class, later other group member and the instructors would critic the teachers' findings and request them for more elaboration. After the discussion, the instructors summarized the key features of the NOS embedded in the two case histories.

The second half of the semester, the instructors used a video tape which addressed on using demonstration to enhance students' appreciation of the NOS, then discussed with the science teaches how they could address the features of the NOS into their science teaching. After anchoring the NOS teaching, all the science teachers were arranged into five groups, and each group has to provide a lesson plan addressed on the NOS teaching. Each group has to demonstrate their 30 minutes NOS teaching in front of their classmates. At the end of their teaching, each group has to collect critics from their classmates, reflected on their own teaching performance and described how to improve their NOS teaching in their final report.

Research Design and Procedures

A questionnaire, "Understanding of the Nature of Science Scale (Chinese version)" (Lin, 1995), was administered before and after the course. In the end of the semester, each inservice science teacher has to turn in a self-reflective journal addressed their changes on their pre- and post- tests. In addition, weekly group discussion report, teachers' reflective journals were collected during the course processing. Five sets of team members' lesson plans, video-tape of their teaching, peer's critic, individual teacher's self-reflection on teaching performance, and two instructors (researchers) logs were collected at the end of the semester.

The understanding of the nature of science scale

The understanding of the nature of science scale was developed by Lin (1996), which consisted of three scales, these were the nature of scientific method, the nature of scientific knowledge, and the nature of scientific enterprise. Twenty-four items were involved in each scale.

The nature of scientific method scale was defined by understanding the nature of scientific method, especially on the uniqueness, appropriateness, objectivity and rationality of the scientific methods. Example item was: "The interpretation of the laboratory results depended on the theories scientists hold."

The nature of scientific knowledge scale was defined as students' understanding of the nature of scientific knowledge especially on the kinds, roles, ontology and epistemology level of the scientific knowledge. Example item was: "The current scientific knowledge has been proved, there is no doubt on the accuracy of it."

The nature of scientific enterprise scale was defined as students' understanding of the nature of scientific enterprise, especially on the fundamental assumption,

definition, and purposes of science, scientists, scientific community, and the relationship between science and society. Example item was: "Scientists were not necessary more objective than other people."

The validity and reliability of the scale has been proved, the Cronbach α for total questionnaire and the above scales were 0.90, 0.74, 0.79 and 0.77.

Data analysis

For the quantitative data, paired t test and descriptive statistics were used to analyze the questionnaire by items, some results were listed in table I. For the qualitative data, analytic induction method was applied. Researchers went through the qualitative and quantitative data individually, wrote done the temporary findings with evidence. Later, two researchers compared and contrasted with each other's findings and tried to find more evidence to support or to reject the findings. After comparing and contrasting the findings several times, the more abstract level of the findings were established in the study.

Findings

Table I : The significant items between pre- and post tests of the NOS survey

Items	Pre-test Mean/SD	Post-test Mean/SD	T Value	P value
The Nature of Scientific Method Scale				
13 The interpretation of scientific results is constant across the various scientists.	2.05/.61	1.55/.61	3.25	.00**
40 Two scientists observed the same phenomena individually, they must have the same report.	1.85/.49	1.60/.60	2.52	.02*
43 When investigating scientific problem, scientists would follow the same rules to choose scientific methods.	2.15/.49	1.80/.62	2.67	.02*
52 As we followed the particulate scientific methods we can solve the scientific problems.	2.30/.66	1.95/.69	2.67	.02*
The Nature of Scientific Knowledge Scale				
14 The current scientific knowledge has been proved, thus there is no doubt on its' accuracy.	1.90/.31	1.50/.61	2.63	.02*
30 The scientific model is created by scientists' observation of actual objects.	2.55/.83	2.00/.86	2.77	.01**
37 Unless the scientific knowledge is absolute truth, otherwise it could not be accepted as scientific knowledge.	2.30/.92	1.65/.59	2.46	.02*
64 Categorization system has been used by scientists for long period of time, thus it can be accepted without doubt.	2.20/.41	1.80/.52	2.99	.01**
The Nature of Scientific Enterprise Scale				
6 The scientific research is very professional, which did not be accepted by society.	3.55/.83	2.80/.89	3.29	.00**
58 The scientist's new discovery will soon be accepted as common scientific knowledge.	1.90/.31	1.65/.59	2.52	.02*

Note: * $p < .05$, ** $p < .01$.

1. Most of the inservice science teachers were impressed by the subjective and creative nature of generating scientific knowledge, thus teachers' conceptions of the NOS related to the subjective, creative and tentative nature of scientific knowledge were changed dramatically before and after the course.

In the beginning of the course, most of the science teachers talked and wrote of the scientific inquiry as very objective process. However after they read thought how Snow discovered Cholera, and how Black discovered that heat is not an substance. They were very surprised on the subjectivity and creativity of the scientists in using scientific inquiry, which was totally opposite than their previous conceptions. After the course, the test results and science teachers' own self analysis report indicated that their conceptions of the NOS changed dramatically on the subjectivity, creative and tentative nature of the scientific inquiry. On the contrary, the other features of the NOS, such as its' human enterprise, and its' empirical-based were not changed much in the course.

In table I, questions related to the subjective, creative, and tentative nature of generating scientific knowledge were changed significantly before and after the course. Such as item 13 "The interpretation of scientific results is constant, which will not be influenced by the people who interpreted the results"($p<.01$); item 40 "Two scientists observed the same phenomena individually, they must have the same report."($p<.05$); item 43 "When investigating scientific problem, scientists would follow the same rules to choose scientific methods" ($p<.05$); item 52 "As we followed the particulate scientific methods we can solve the scientific problems"($p<0.5$); item 14 "The current scientific knowledge has been proved, thus there is no doubt on its' accuracy"($p<0.5$); item 30 "The scientific model is created by scientists' observation of actual objects"($p<.01$); item 37 "Unless the scientific knowledge is absolute truth, otherwise it could not be accepted as scientific knowledge"($p<.05$); item 64 "Categorization system has been used by scientists for long period of time, thus it can be accepted without doubt"($p<.01$). Based on the above items, it could be categorized into three domains, scientific method, scientific knowledge and scientific enterprise. In the scientific method, most of the inservice science teachers' conceptions have been changed that the nature of the inquiry was very creative and varied by individual. In terms of the inservice science teachers' conceptions of the nature of scientific knowledge, they realized that the existence of the scientific knowledge should not be treated as an absolutely truth, it should be accepted with suspicions. The scientific model is generated by imagination instead of by analytic induction.

2. The inservice science teachers were impressed by the human nature of scientists and how social value and contemporary culture influenced scientists in generating scientific knowledge. Therefore, toward the end of the course, they realized that scientists are subjective, persist with their own ideas, and scientific knowledge were influenced by human society.

In the beginning of the course, many science teachers thought that scientists are calm, they act and behave objective in all aspects of their life. After reading the two cases in the course, most of the science teachers were amazed how subjective of scientists in generating scientific knowledge. They realized that scientists were very persistent in their own reasoning and in conducting research, they also understand how scientific community influenced whether certain view of science would be accepted or not. In terms of the scientific enterprise, most of the teachers' conceptions have changed to the public scientific knowledge need to be proved by the scientific community and by the society. In other words, it is not independent from the society. For instance, in Table I, item 6 "The scientific research is very professional, which did not be accepted by society" ($p<.01$); item 58 "The scientist's new discovery will soon be accepted as common scientific knowledge"($p<.05$). This subjective view of scientific knowledge also influenced them in thinking the tentative view of scientific knowledge.

After reading these two cases, I could feel more closer to these scientists than before. I realized that although different scientists have different personality, but their commonality was persistence. (Journal, 3/10/98, ST021)

Scientists are not necessary all calm and objective. For instance, if Rumford dropped his theory based on the negative evidence from his experiments, then he could not be so successful. (Journal, 4/01/98, ST0021)

What is your impression on the scientists? After reading this book, is there any point of view you had made change?
Before: Scientists are objective, calm nature observer. Do not pursuit reputation and money.
After: Scientists are the same as ordinary people, they still hold certain subjectivity. They are very persistence, and try to make other people accept their point of view(Group 3 discussion, 4/1/98).

I always respect and admire scientists, after reading the historical cases, I

realized that scientists need to maintain their own reputations to do all kinds of things, some made results before experiment. Data collection and interpretation would also depended on individual scientists, which make results differ from each other. Scientists are not necessary all objective all the time. (Final report, ST 037).

My preconceptions of the scientists were that they were very objective and calm nature observers, they only care of reality and pursuit truth. If the lab results did not obey their theory, they would discard their theory. In fact, all the scientists were the same as human being, all their actions depended on their motivation, some motivation is altruism others are self-demanded(Final report, ST 027).

3. In terms of the inservice science teachers' preferred NOS teaching, they tended to provide lab activities and create group work learning context, where students could manipulate the activities, capture the social negotiation process and the inquiry feature of the NOS.

Although two instructors had addressed many features of the NOS, all way through the course, such as the creative and theory-laden of scientific knowledge, the generalizability of scientific theory, inquiry nature, and scientific attitude in the course. We also demonstrated the above features by verbal expression and by requesting inservice science teachers acting like scientists in discussing the questions on the worksheets. But when analyzing teachers' lesson plans, their peer's comments and observing teachers' teaching, it showed that science teachers preferred to provide group work for students to acquire the NOS. Because during group work, teachers expected students to conduct experiment, discuss, share and negotiate ideas by themselves and among peers. This kind of group work context could help students automatically appreciate some features of NOS, particular on the social negotiation process of generating scientific knowledge.

I thought the NOS teaching is to address exploration, discussion and reporting, teacher should give few lecture, he(she) needs to provide opportunities for students to observe the nature phenomena; lead students to have learning motivation; stimulate students' desire to pursuit knowledge; design questions for students to answer; provide opportunities for students to discuss the conclusion; have students to report their findings and revising their conclusion, etc. All the processes could have students appreciate how scientific knowledge were generated. (Final

report, ST008).

After students conduct lab activities, I encouraged students to explain their data based on their own reasoning and did not necessary obey what the textbook told.(Final report, ST008)

Based on each team's presentation, their teaching addressed that students could learn science by actual manipulate, explore, conclude, and integrate scientific knowledge. They could also use observation to spark their thought, these were very good science teaching. (Final report, ST041)

- *All teams provided actual experiment activities, having students to manipulate , observe, and explore the scientific knowledge behind the activities.(Final report, ST 032)*

4. After enhancing the NOS conceptions, many of science teachers substituted the verification type of experiment into providing daily life problem for students to enhance their inquiry and problem solving ability.

Many science teachers mentioned in their journal that before the course, they always thought of the importance of verifying the never-changing nature of scientific principles in the experiments. Therefore, most of the teachers provided correct procedures and results before students conducting the experiment. However, after they acquired the current conceptions of the NOS, and appreciated the nature of scientific inquiry, they started to change their teaching of NOS in focusing on the students' abilities in inquiry and solving daily life problem..

After you read through the two cases of the scientific history, which aspects influenced on your teaching?

When teaching experiment, do not tell them (students) results before conduct experiment. When you (students) find out unexpected research results or error you need to analyze the reasons behind.(group discussion, 4/01/98, Group 4)

Before taking this course, I always tried to find daily life examples for students to comprehend the knowledge that I tried to teach in the class...But now, I realized that only comprehension is not enough, students need to create knowledge and learn problem solving ability...I

tried to use constructivist teaching method in my own class. For instance I gave students some beads, and then having them to identify whether these bears are nature or artificial. They could use many methods to identify them ... some of them use density, others use hardness, etc .... Students all concentrated in learning ... After that experience, I could really feel the pleasure of teaching. (Final report, ST012)

I used some societal issue such as reproduction of human being, asked students to think of how to solve these problems ... asked open-ended questions to stimulate students to explore and to learn by themselves. Asking questions from many perspectives could practice students' thinking ability. (Final report, ST024)

Factors influenced science teachers in changing their conceptions and practicing of the NOS

1. Science teachers' image of the scientists were the major factor which influenced them in changing the objectives of the scientific knowledge to subjective and tentative.

We offered two historical cases which described how scientists discovered Cholera and the substance of heat (Goldstein & Goldstein, 1978). In two cases, the authors tried to address the subjective of the scientists in conducting the research. Thus most of science teachers were very surprised that scientists act like ordinary people who are emotional, very stubborn, and persistent in conducting their research. Only after these teachers realized that scientists' human nature, made them change their views from the objectives to the subjective of the scientific knowledge.

Do you think scientists can maintain absolutely objective in conducting scientific research?

Scientists would also predict the possible results of the experiment, thus it would inclined the human error in recording data ... Experimenters interpret the data inappropriately would derive error conclusions. (Group discussion, 3/11/98, group 4)

I always thought scientific knowledge is based on scientists using scientific method to generate knowledge. If a group of people (scientists) used objective analysis and discussion to generate knowledge, it should be very objective ... Not until Dr. Chin's explanation, I realized Kopanny advocatd that the earth is moving around the sun, but at the time none of the people would accept his theory so he finished his life. But now

nobody disagree his theory. Thus a group of people's ideas did not mean they are right. Which means a group of people's discussion are not necessary objective, which all influenced by one's value judgement, and the cultural background we lived by...Right now I realized that scientific knowledge and scientists are not objective.(Final report, ST026)

2. The inservice science teachers' views of the NOS teaching were reinforced and integrated by this course teaching methods and other pedagogy courses offered in the inservice program.

Examining each group of teachers' lesson plan and their demonstration; all of them incorporated group work and small group discussion as part of their NOS teaching. However, besides those activities, teachers still played the major role in transmitting science knowledge to students. From our perspective, we had role played in the course, and also verbally reminded and encouraged inservice science teachers act like scientists in learning science. Unfortunately, only one out of five groups of teachers used the methods suggested by researchers. Basing on teachers' final report and peer's critics, the majority of the science teachers addressed the cooperative learning and constructivist learning were the best methods for them to address the NOS. In fact, these thought were advocated and reinforced by other courses they took in this science teacher education program. This course offered activities for the science teachers to integrate what they had learned about constructivist teaching and cooperative learning into deeper appreciation and implementation.

Professors (Tuan and Chin) used group discussion, presentation, providing supportive evidence, and encouraged using reasoning to persuade other people. All the teaching methods could made me experience and appreciate the dialectical process of generating scientific knowledge. (Final report, ST 007)

I liked the reconstruction of the dinosaur born structure activities. Different people constructed different dinosaur using the same pieces of born, which made me think of the process of scientific knowledge. There are no absolute knowledge, knowledge is invented by human being...(Final report, ST 024)

Last semester, we took Dr. Chen's constructivist teaching, I felt like I need to change my science teaching dramatically...This semester after I read the "How we know" book, I feel like that the spirit of constructivist is the

same as the spirit of the NOS. (Final report, ST 008)

Dr. Tuan asked us to read some paper before the course, and then gave us some questions to discuss in the class. These activities made me to reshape of my preconceptions of the NOS. (Final report, ST 041)

Last semester, we took Dr. Lee's course, he had mentioned about the NOS and the difference between science and pseudo-science. But it was more theory-oriented, this semester, Dr. Tuan used more concrete cases for us to appreciate the NOS, which changed my perceptions of the scientists. (Final report, ST 019)

Discussion and Conclusion

The finding of the study supported the previous research findings that case study was the best way to help science teachers appreciate the NOS (Mathews, 1994, 1998; Scharmann & Harris, 1992; Solomon, Duveen, Scot, & McCarthy, 1992). In our study we think the case study could help inservice science teachers appreciate the tentative, creative, and subjective nature of scientific inquiry, and the characteristic of the scientists. We also found out teachers' familiar with the subject, creative, and tentative nature of scientific inquiry and the human nature of scientists were the main factor which changed teachers' conceptions of the NOS. Even though we used many verbal explanation, and assigned reading to introduce many aspects of the NOS, these teachers were still impressed by the authentic nature of scientific inquiry and ignored the rest aspects of the NOS. We think these science teachers might use personification way to construct the meaning of the NOS. Therefore, even though we addressed other features of the NOS, these features were difficult for them to connect to their previous conceptions of the objectivity of science, therefore majority features of the NOS did not change significantly after the course.

In terms of teaching the NOS, these science teachers preferred providing group work context and discussion for students to appreciate the NOS. The also changed their verification way in conducting experiment to have students apply problem solving strategies to investigate problem around students' daily live. However, these science teachers seldom used role modeling and verbal encouragement for students to act like scientists and to help students appreciate many features of the NOS. The study also found out these teachers did not apply their new conceptions of the NOS in generating teaching strategies. Their NOS teaching were influenced by their learning experience in many instructors' constructivist teaching, which was the key feature in the inservice science education program. They did not apply their new

conceptions of the NOS in generating teaching strategies. Thus, although they realized the subjective nature of scientific knowledge, they still did not design any teaching strategies or verbally emphasized in the class.

The discrepancy of teachers' new conceptions and teaching of the NOS was existed. One reason is that the science teachers' previous conceptions of the NOS still dominate their teaching, which made them still address on the introducing of scientific knowledge. Second, teachers need to take a longer time to digest their new conceptions of the NOS in order to act out in their future science teaching. Third, teachers need to have specific teaching methods to teach any aspects of the NOS. No matter which reason is legitimate, we think it is important that helping inservice science teaches to teach the NOS need time and constant support. Although we identified some factors which influenced the science teachers' in acquiring the NOS and practicing the NOS. Future research still need to fins ways to facilitate teachers' conceptions of the NOS into classroom teaching.

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